CLAIMS

1. An apparatus for controlling a plasma used for materials processing, the apparatus comprising:

   a resonant circuit in electrical communication with an output of a power supply and an input of a plasma vessel, the resonant circuit for storing and releasing energy;

   a sensor for acquiring a signal associated with a state of a plasma in the plasma vessel; and

   a switch unit switchable between a first state and a second state in response to the signal, the second state of the switch unit for shunting the resonant circuit to permit a resonance of the resonant circuit that causes a change in the state of the plasma.

2. The apparatus of claim 1, wherein the resonant circuit comprises an inductor, and the sensor is configured to sense a flux induced by the inductor.

3. The apparatus of claim 2, wherein the sensor is coaxially disposed adjacent to the inductor of the resonant circuit.

4. The apparatus of claim 1, wherein the switch unit has a resistance that is large enough to effectively act as a damping impedance for the resonant circuit during shunting.

5. The apparatus of claim 4, wherein the switch unit has a resistance that is less than a resistance of an arc discharge plasma in the plasma vessel.

6. The apparatus of claim 4, wherein the switch unit has an impedance that is greater than an impedance of an arc discharge plasma in the plasma vessel.

7. The apparatus of claim 4, wherein the resistance of the switch unit has a value in a range of approximately 0.001 Ω to approximately 100.0 Ω.

8. The apparatus of claim 1, further comprising a controller for receiving the signal from the sensor, and for causing the switch unit to switch to at least one of the first state and the second state to affect the state of the plasma.

9. The apparatus of claim 8, wherein the controller is configured to cause the switch unit to switch to the second state when a transition of the state of the plasma is indicated by a change in the signal.

10. The apparatus of claim 1, further comprising a voltage clamp circuit in parallel with the input of the plasma vessel.

11. The apparatus of claim 10, wherein the voltage clamp is an asymmetric voltage clamp.

12. The apparatus of claim 1, further comprising a zero-bias supply unit in series with the switch unit for applying to the switch unit an offset voltage associated with a voltage drop caused by a resistance of at least one of the switch unit and parasitic circuit elements associated with the switch unit.

13. The apparatus of claim 1, further comprising a voltage sensor for sensing a voltage of at least one of the resonant circuit, the power supply, and the input of the plasma vessel.

14. The apparatus of claim 1, further comprising a current sensor for sensing a current of at least one of the resonant circuit, the power supply, and the input of the plasma vessel.

15. The apparatus of claim 1, wherein the switch unit comprises at least one switch.

16. The apparatus of claim 15, wherein the resonant circuit comprises an inductor, and the switch unit has one terminal electrically connected between the inductor and the input of the plasma vessel.

17. The apparatus of claim 15, wherein the switch unit comprises at least one of a unipolar device and a bipolar device.

18. The apparatus of claim 15, wherein the switch unit comprises at least one of a gas switch, a SCR switch, an IGBT switch, an SiT switch, a FET switch, a GTO switch, and a MCT switch.

19. The apparatus of claim 1, wherein the resonant circuit comprises a capacitor in parallel with the switch unit.

20. The apparatus of claim 1, wherein the power supply comprises a capacitor in parallel with the output of the power supply, and in parallel with a capacitor of the resonant circuit.

21. The apparatus of claim 20, wherein the resonant circuit further comprises an inductor in series with the output of the power supply.

22. The apparatus of claim 1, wherein the plasma vessel comprises a cathode in electrical communication with the output of the power supply, and the power supply comprises a DC supply.

23. The apparatus of claim 1, wherein the power supply comprises an AC supply in electrical communication with the plasma vessel.

24. The apparatus of claim 1, wherein the resonant circuit and the power supply share components.

25. A method for controlling a plasma used for materials processing, the method comprising:

providing a resonant circuit in electrical communication with an output of a power supply and an input of a plasma vessel, the resonant circuit for storing and releasing energy;

detecting a change that indicates a transition of a state of a plasma in the plasma vessel; and

shunting the resonant circuit after the change is detected to permit a resonance of the resonant circuit.

26. The method of claim 25, wherein shunting comprises extinguishing the plasma in the plasma vessel.

27. The method of claim 26, wherein shunting comprises causing the plasma to extinguish in less than 10 μsec.

28. The method of claim 25, further comprising acquiring a signal associated with the state of the plasma, and wherein detecting comprises detecting the change in the signal.

29. The method of claim 25, wherein the plasma is at least one of a glow plasma and an arc discharge plasma.

30. The method of claim 25, wherein shunting comprises substantially reducing a current flowing through the plasma vessel during an initial half cycle of the resonant circuit relative to a current flowing through the vessel prior to the initial half cycle.

31. The method of claim 25, wherein the transition comprises initiation of an arc discharge plasma from a glow plasma in the plasma vessel, and shunting comprises shunting for a half cycle of the resonant circuit.

32. The method of claim 31, further comprising providing a switch unit for shunting the resonant circuit, and shunting comprises closing the switch for the half cycle of the resonant circuit.

33. The method of claim 31, further comprising waiting for a half cycle before again shunting if the arc discharge plasma persists.

34. The method of claim 33, further comprising repeating shunting and waiting until the change is no longer detected.

35. The method of claim 34, further comprising acquiring at least a second signal comprising at least one of a voltage signal and a current signal of at least one of the resonant circuit, the power supply, and the plasma vessel, wherein repeating comprises repeating if the at least second signal indicates a persistent arc discharge plasma.

36. The method of claim 34, wherein shunting comprises causing the power supply to shut down when repeating occurs more than a predetermined number of times.

37. The method of claim 36, wherein shunting comprises causing the power supply to shut down when repeating occurs more than the predetermined number of times within a predetermined period.

38. The method of claim 25, further comprising acquiring at least a second signal comprising at least one of a voltage signal and a current signal of at least one of the resonant circuit, the power supply, and the plasma vessel, and detecting a change in the second signal that indicates the transition of the state of the plasma.

39. The method of claim 25, further comprising detecting a second change in the acquired signal, the second change indicating extinguishment of the plasma.

40. The method of claim 39, further comprising reigniting the plasma in the plasma vessel.

41. The method of claim 40, wherein reigniting comprises shunting the resonant circuit to increase an energy stored in the resonant circuit, and removing the shunt to direct the stored energy to the input of the plasma vessel to ignite the plasma in the plasma vessel.

42. The method of claim 41, wherein shunting to increase the stored energy comprises shunting the resonant circuit until the resonant circuit causes a current of the power supply to be greater than a steady-state current of an arc discharge plasma, and removing the shunt comprises commuting the current to the input of the plasma vessel to ignite an arc discharge plasma in the plasma vessel.

43. The method of claim 41, wherein shunting to increase the stored energy comprises shunting the resonant circuit for an effective portion of a cycle of the resonant circuit to increase an energy stored in the resonant circuit, and removing the shunt comprises directing the stored energy to the input of the

plasma vessel after the effective portion of the cycle to ignite a glow discharge plasma in the plasma vessel.

44. The method of claim 25, wherein the resonant circuit comprises an inductor in series with the output of the power supply and the input of the plasma vessel, and sensing the signal comprises sensing a flux induced by the inductor.

45. The method of claim 25, wherein the transition of the state of the plasma is one of a glow plasma state to an arc discharge plasma state, an arc plasma state to a glow plasma state, an arc discharge plasma state to an off state, a glow plasma state to an off state, an off state to an arc discharge plasma state, and an off state to an arc discharge plasma state.

46. The method of claim 25, wherein the resonant circuit comprises a capacitor and inductor, and shunting comprises causing a current to resonate in the resonant circuit to cause a reversal of a current applied to the input of the plasma vessel.

47. The method of claim 46, further comprising clamping the reversed current to limit the magnitude of the reversed voltage to less than a predetermined magnitude.

48. A method for igniting a plasma used for materials processing, the method comprising:

providing a resonant circuit in electrical communication with an output of a power supply and an input of a plasma vessel, the resonant circuit for storing and releasing energy;

shunting the resonant circuit to increase an energy stored in the resonant circuit; and

removing the shunt to direct the stored energy to the input of the plasma vessel to ignite the plasma in the plasma vessel.

49. The method of claim 48, wherein shunting comprises shunting the resonant circuit until the resonant circuit causes a current of the power supply to be greater than a steady-state current of an arc plasma, and removing the shunt

comprises commuting the current to the input of the plasma vessel to ignite an arc plasma in the plasma vessel.

50. The method of claim 48, wherein shunting comprises shunting the resonant circuit for an effective portion of a cycle of the resonant circuit to increase an energy stored in the resonant circuit, and removing the shunt comprises directing the stored energy to the plasma vessel after the effective portion of the cycle to ignite a glow plasma in the plasma vessel.

51. The method of claim 50, wherein the effective portion of the cycle is a half cycle.

52 . The method of claim 48, further comprising sensing a signal associated with a state of a plasma in the plasma vessel.

53. The method of claim 52, further comprising repeating shunting and removing the shunt if the signal indicates failure to ignite a desired plasma state.

54. The method of claim 53, wherein repeating comprises repeating until one of a glow plasma is ignited, a predetermined number of failures to ignite the glow plasma occur, and a predetermined period of failure expires.

55. The method of claim 53, wherein repeating comprises repeating until one of an arc discharge plasma is ignited, a predetermined number of failures to ignite the arc discharge plasma occur, and a predetermined period of failure expires.

56. The method of claim 52, further comprising shunting to extinguish a plasma in the plasma vessel if the signal indicates an undesired plasma state of the plasma in the plasma vessel.

57. The method of claim 56, further comprising shunting to extinguish a plasma in the plasma vessel if the signal indicates an undesired plasma state of the plasma in the plasma vessel.

58. The method of claim 48, wherein most of the stored energy is stored by an inductor of the resonant circuit.

59. The method of claim 58, wherein the inductor of the power supply or a portion of the inductor of the power supply is shared by the resonant circuit.

60. The method of claim 48, wherein most of the stored energy is stored by an inductor of the power supply.

61. The method of claim 60, wherein the inductor of the power supply has a larger inductance than an inductor of the resonant circuit.

62. The method of claim 25, wherein detecting the change that indicates the transition of the state of the plasma comprises detecting a change that anticipates the transition of the state of the plasma.

62. The method of claim 62, wherein shunting the resonant circuit after the change is detected comprises shunting prior to the transition occurring.